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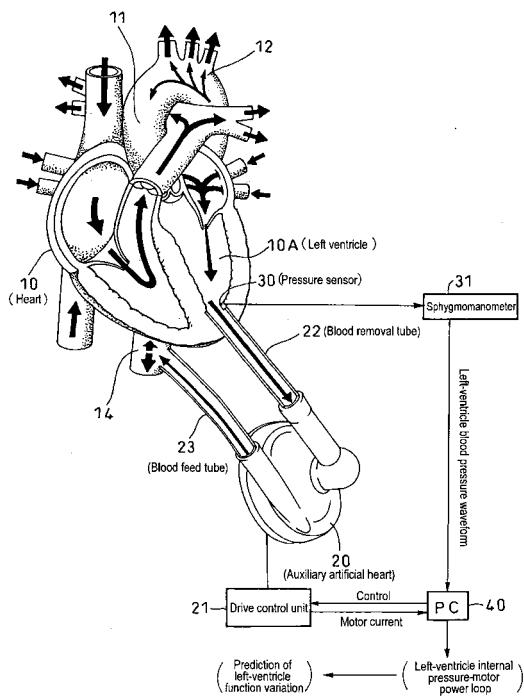
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(54) **CARDIAC FUNCTION CHANGE EVALUATING DEVICE**

(57) A cardiac function variation evaluation apparatus includes: a continuous flow type auxiliary artificial heart 20 connected to a ventricle (10A); a pressure sensor 30 for detecting ventricle (10A) internal pressure; and means (a personal computer 40) for evaluating contractile variation of the ventricle, to which the auxiliary artificial heart 20 is connected, based on internal area APMp of a closed-loop of a relationship between the ventricle internal pressure detected by the pressure sensor 30 and a consumption power of the auxiliary artificial heart 20. Thus, the contractile variation of the ventricle, to which an auxiliary artificial heart is connected, can be continuously evaluated not by use of an ultrasonic echo apparatus or a conductance catheter but by use of a non-invasive method.

【Fig. 2】



Description

[Technical Field]

5 [0001] The present invention relates to a cardiac function variation evaluation apparatus, more particularly, it relates to a cardiac function variation evaluation apparatus capable of continuously evaluating contractile variation of a ventricle, to which an auxiliary artificial heart is connected, not by use of an ultrasonic echo apparatus or a conductance catheter to be inserted into the ventricle through a peripheral blood vessel but by use of a non-invasive method.

10 [Background Art]

15 [0002] The applicant has proposed a continuous flow type auxiliary artificial heart constituted by a centrifugal pump, the auxiliary artificial heart being disclosed in Japanese Published Unexamined Patent Application No. 2007-44302 (Patent Document 1). In the case where such an auxiliary artificial heart is connected, a cardiac function of a person having the connected auxiliary artificial heart sometimes recovers, and cardiac function variation, more particularly, contractile variation of a left ventricle, is sometimes desired to be evaluated.

20 [0003] On the other hand, as one of the methods for evaluating the cardiac function variation, more particularly, the contractile variation of the left ventricle, there is a method for inserting a conductance catheter into the left ventricle, calculating an internal area of a closed-loop from a relationship between left ventricle internal pressure and left ventricle internal volume, the relationship being indicated in Fig. 1, and then evaluating the cardiac function variation, the method being disclosed in Japanese Published Unexamined Patent Application No. 2002-143109 (Patent Document 2). The closed-loop area (stroke volume) in Fig. 1 corresponds to workload.

25 [0004] However, in the conventional method, it is necessary to use an expensive ultrasonic echo apparatus or to insert the conductance catheter into the left ventricle of the person having the connected auxiliary artificial heart. Therefore, the method is invasive, and not only imposes a burden on the person, but also has a possibility of causing infection or a thrombus in the case of long-time use.

[Disclosure of the Invention]

30 [0005] The present invention was made in order to solve the above conventional problem, and aims at continuously evaluating contractile variation of a ventricle, to which an auxiliary artificial heart is connected, not by use of an ultrasonic echo apparatus or a conductance catheter but by use of a non-invasive method.

35 [0006] According to experiments by the inventors, it is possible to prepare a graph indicating a relationship between left ventricle internal pressure and a motor consumption power as indicated in Fig. 3 based on a consumption power wave obtained by multiplying a current wave of a motor of a continuous flow type left ventricle auxiliary artificial heart 20 shown in Fig. 2 and motor voltage; and the internal pressure of a left ventricle 10A, the internal pressure being detected by a pressure sensor 30 built in a blood removal tube 22, and possible to, as indicated in Fig. 4, obtain a sufficient correlation between a closed-loop internal area $APMp$ of the above relationship and an external work EW for circulating blood through the whole body including the left ventricle 10A and the auxiliary artificial heart 20. The correlation indicates that, regardless of characteristics of a pump of the artificial heart, the contractile variation of the left ventricle, to which the auxiliary artificial heart is connected, can be evaluated based on the closed-loop internal area $APMp$.

40 [0007] The present invention was made based on such knowledge, and solves the above problem by providing a cardiac function evaluation apparatus including: a continuous flow type auxiliary artificial heart connected to a ventricle; a pressure sensor for detecting the ventricle internal pressure; and means for evaluating contractile variation of the ventricle, to which the auxiliary artificial heart is connected, based on a relationship between the ventricle internal pressure detected by the pressure sensor and a consumption power of the auxiliary artificial heart.

45 [0008] Here, the contractile variation of the ventricle, to which the auxiliary artificial heart is connected, can be evaluated based on a closed-loop internal area of the relationship between the ventricle internal pressure and the consumption power of the auxiliary artificial heart.

50 [0009] Additionally, the pressure sensor can be built in a blood removal cannula for connecting the ventricle and the auxiliary artificial heart.

[0010] Additionally, as the auxiliary artificial heart, a diagonal flow pump, a centrifugal pump or an axial flow pump is applicable.

55 [0011] According to the present invention, it is possible to evaluate the contractile variation of the ventricle, to which the auxiliary artificial heart is connected, not by use of an ultrasonic echo apparatus or a conductance catheter but by use of a non-invasive method.

[Brief Description of the Drawings]

[0012]

5 Fig. 1 is a graph indicating one cycle using left ventricle internal pressure and a volume loop regarding the left ventricle.
 Fig. 2 is a view showing an embodiment of the present invention.
 Fig. 3 is a graph indicating a relationship between the left ventricle internal pressure and a motor consumption power of an auxiliary artificial heart, the relationship explaining the principle of the present invention.
 Fig. 4 similarly is a graph indicating an example of a relationship between a closed-loop internal area APMp calculated based on the motor consumption power and an external work calculated based on the left ventricle internal pressure and the volume loop.
 10 Fig. 5 is a view showing a partial bypass state of the embodiment. [Best Mode for Carrying Out the Invention]

[0013] Hereinafter, an embodiment of the present invention will be described in detail with reference to the drawings.

15 [0014] As shown in Fig. 2, a cardiac function variation evaluation apparatus of the embodiment includes: a continuous flow type auxiliary artificial heart 20 connected to a left ventricle 10A of a heart 10 and a drive controller 21 of the same; a pressure sensor 30 for detecting internal pressure of the left ventricle 10A and a sphygmomanometer 31; and a personal computer (PC) 40 for evaluating contractile variation of the left ventricle, to which the auxiliary artificial heart is connected, based on a closed-loop internal area APMp of a relationship between the left ventricle internal pressure detected by the pressure sensor 30 and a motor consumption power of the auxiliary artificial heart 20.

[0015] In Fig. 2, the reference symbol 11 denotes an ascending aorta, 12 denotes an aortic arch, 14 denotes a descending aorta, and 23 denotes a blood feed tube.

[0016] As the auxiliary artificial heart 20, a diagonal flow pump is usable, for example. Alternatively, a centrifugal pump or an axial flow pump, etc., may be used.

25 [0017] It is desirable that the pressure sensor 30 is provided on an wall at the top end of a blood removal cannula 22 for connecting the left ventricle 10A and the auxiliary artificial heart 20, the wall being in the vicinity of the ventricle.

[0018] A graph indicating a relationship as shown in Fig. 3 between the left ventricle internal pressure and the motor consumption power is prepared based on the motor consumption power of the auxiliary artificial heart 20 and an output of the pressure sensor 30, which are calculated by using a simulated circulation circuit or a conventional conductance catheter and the like in an animal experiment. Then, a relationship between the calculated closed-loop internal area APMp and a loop internal area of the left ventricle pressure and volume which is calculated by using a conventional conductance catheter and the like, is obtained in advance, and a relational expression as indicated in Fig. 4 is prepared.

30 [0019] As shown in Fig. 2, in a full bypass state in which the heart is weak and a valve is not opened, a high correlation (correlation coefficient: $r \approx 0.94$) as indicated by a solid line A in Fig. 4, is obtained in which an external work EW is small relative to the closed-loop internal area APMp.

[0020]

40 Solid line A: $EW = 20 \text{ APMp} - 230 \dots (1)$

[0021] On the other hand, in the case of a partial bypass state where the heart recovers and an aorta valve is opened as shown in Fig. 5, the external work EW becomes relatively high and the correlation becomes slightly worse (correlation coefficient: $r \approx 0.87$) as indicated by a broken line B in Fig. 4.

45 [0022]

Broken line B: $EW = 27 \text{ APMp} - 390 \dots (2)$

50 [0023] Accordingly, if variation of the closed-loop internal area APMp is continuously monitored, it suggests that the contractile variation of the left ventricle can be presumed.

[0024] Moreover, although the diagonal flow pump is employed as the auxiliary artificial heart in the embodiment, the present invention is not limited to it. The present invention is also applicable to the centrifugal pump proposed by the Applicant in Patent Document 1, or the axial pump.

[Industrial Applicability]

5 [0025] The present invention is usable for the case of continuously evaluating contractile variation of a ventricle, to which an auxiliary artificial heart is connected, not by use of an ultrasonic echo apparatus or a conductance catheter to be inserted into the ventricle through a peripheral blood vessel but by use of a non-invasive method.

Claims

10 1. A cardiac function variation evaluation apparatus comprising:

a continuous flow type auxiliary artificial heart connected to a ventricle;
a pressure sensor for detecting ventricle internal pressure; and
15 means for evaluating contractile variation of the ventricle, to which the auxiliary artificial heart is connected, based on a relationship between the ventricle internal pressure detected by the pressure sensor and a consumption power of the auxiliary artificial heart.

20 2. The cardiac function variation evaluation apparatus according to claim 1, wherein the contractile variation of the ventricle, to which the auxiliary artificial heart is connected, is evaluated based on an internal area of a closed-loop of the relationship between the ventricle internal pressure and the consumption power of the auxiliary artificial heart.

25 3. The cardiac function variation evaluation apparatus according to claim 1, wherein the pressure sensor is built in a blood removal cannula via which the auxiliary artificial heart is connected to the ventricle.

4. The cardiac function variation evaluation apparatus according to claim 1, wherein, as the auxiliary artificial heart, a diagonal flow pump, a centrifugal pump or an axial flow pump is used.

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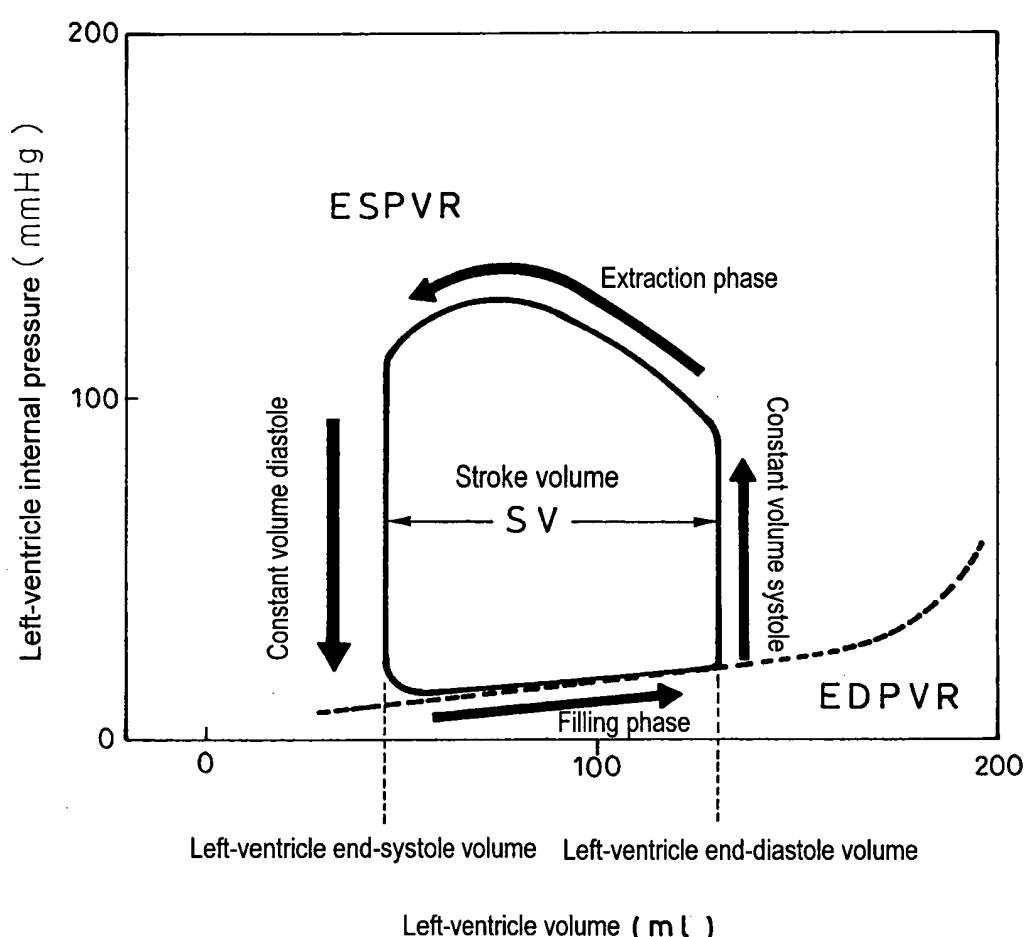
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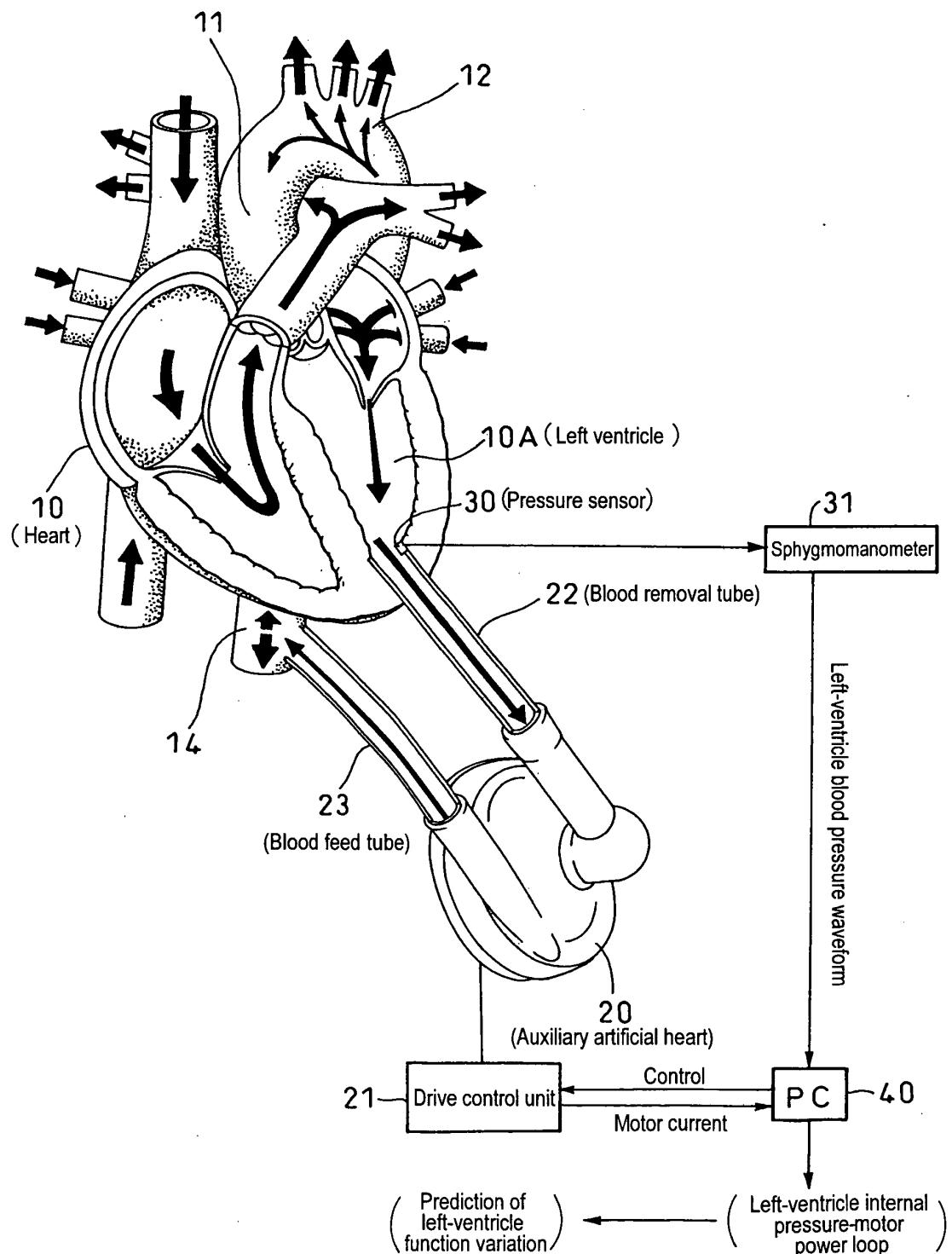
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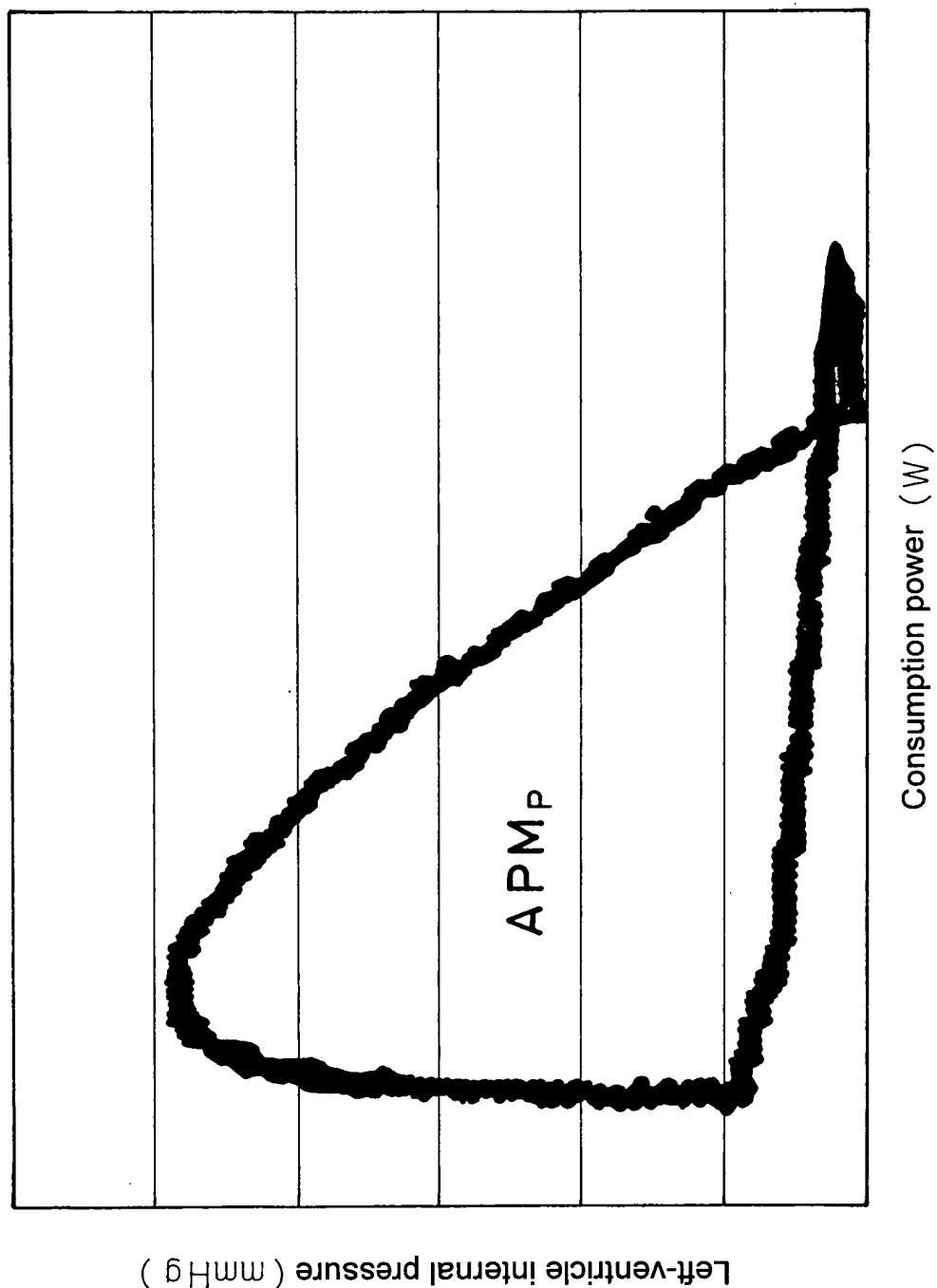
【 Fig. 1 】



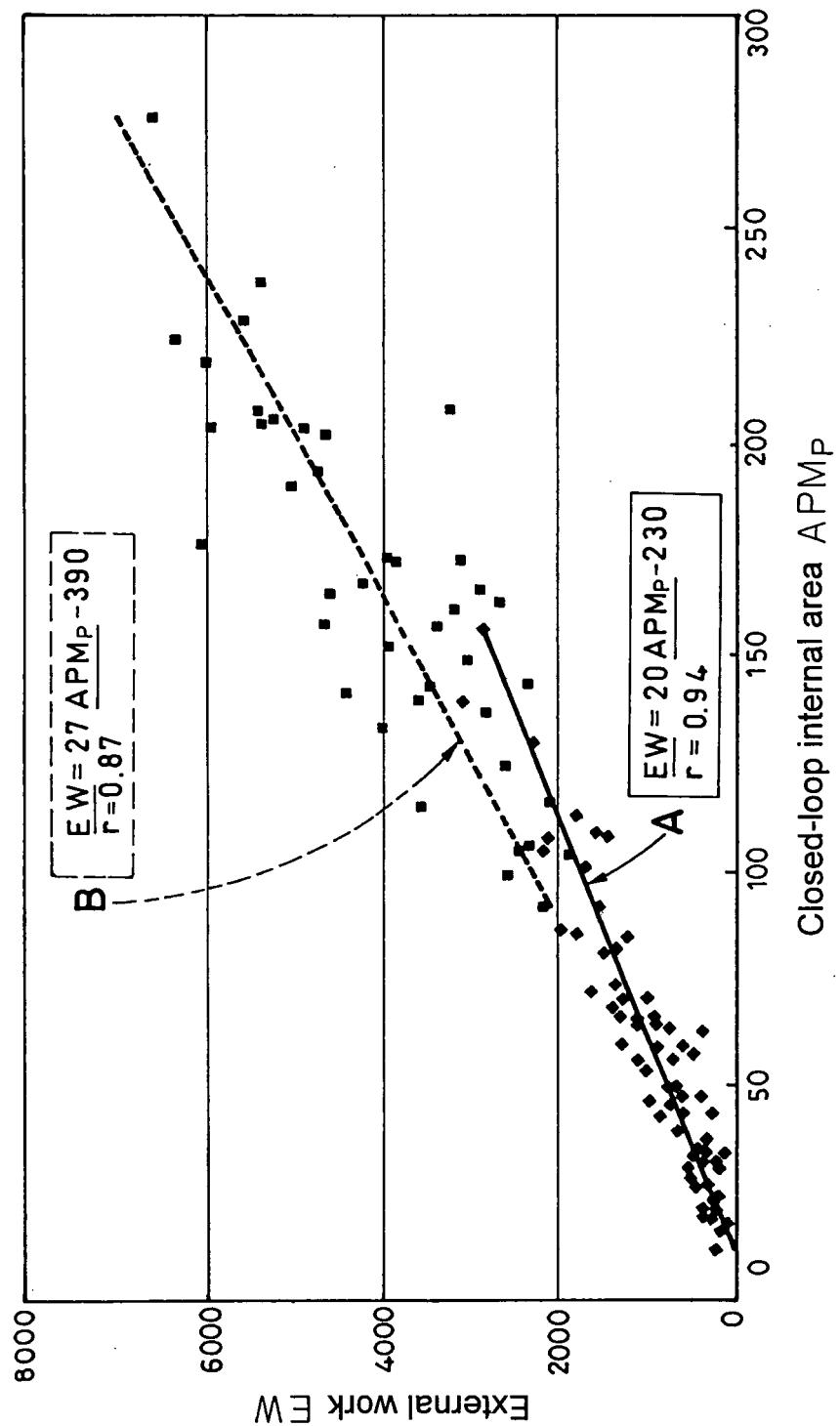
【 Fig. 2 】



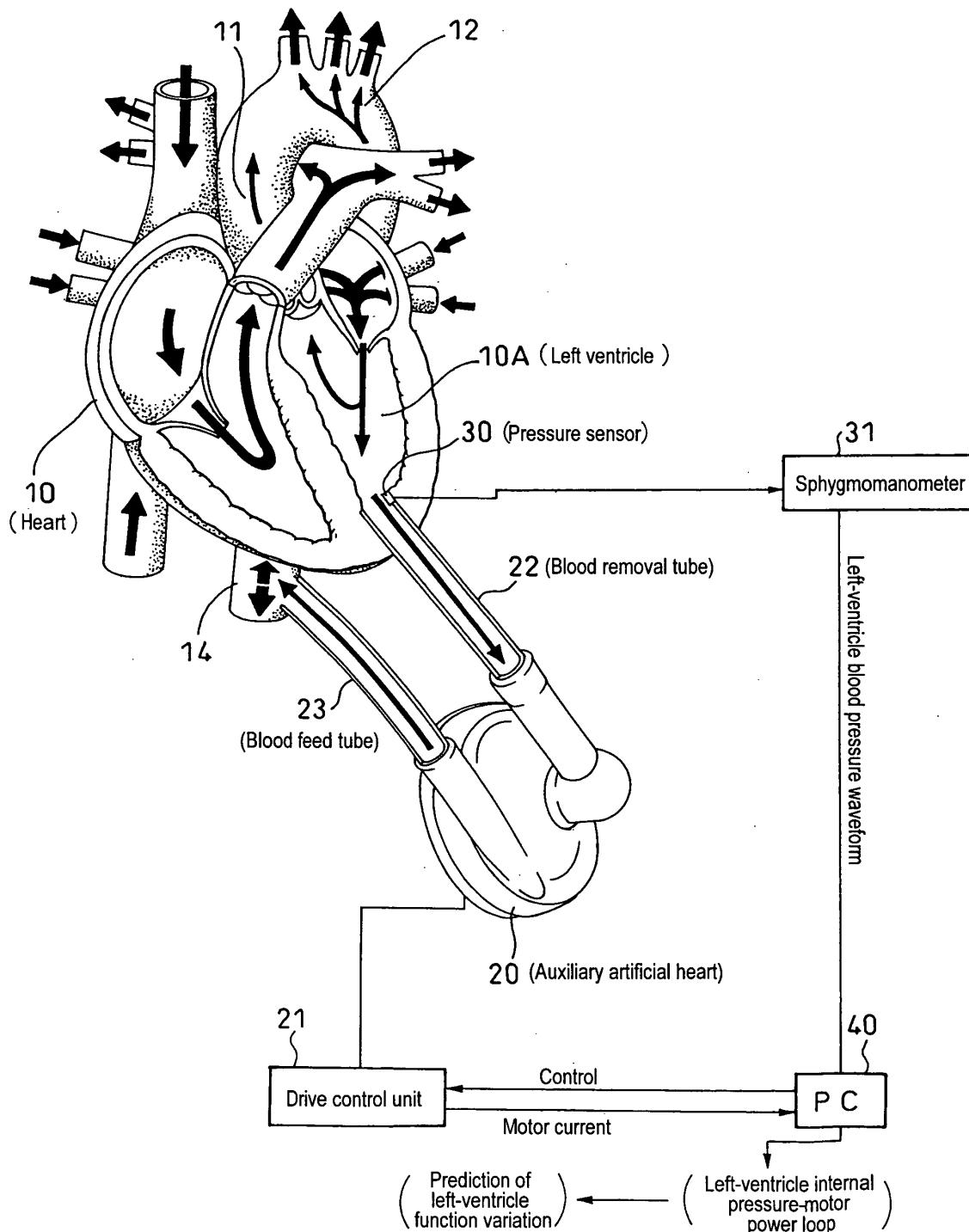
[Fig.3]



[Fig.4]



【Fig. 5】



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/058610

A. CLASSIFICATION OF SUBJECT MATTER
A61M1/10(2006.01)i, A61B5/0215(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61M1/10-1/12, A61B5/00-5/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2008
Kokai Jitsuyo Shinan Koho 1971-2008 Toroku Jitsuyo Shinan Koho 1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 1999/033502 A1 (JMS Co., Ltd.), 08 July, 1999 (08.07.99), Full text; all drawings & US 6572530 B1 & EP 1046403 A1	1-4
A	JP 2006-500982 A (Ventrassist Pty Ltd.), 12 January, 2006 (12.01.06), Full text; all drawings & WO 2004/028593 A1 & EP 1549363 A1	1-4
A	JP 2007-44302 A (Tokyo Medical and Dental University), 22 February, 2007 (22.02.07), Full text; all drawings & WO 2007/018044 A1	1-4

 Further documents are listed in the continuation of Box C. See patent family annex.

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"&"	document member of the same patent family

Date of the actual completion of the international search
18 July, 2008 (18.07.08)Date of mailing of the international search report
29 July, 2008 (29.07.08)Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT		International application No. PCT/JP2008/058610
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2005-80982 A (Miwatec Co., Ltd.), 31 March, 2005 (31.03.05), Full text; all drawings (Family: none)	1-4

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007044302 A [0002]
- JP 2002143109 A [0003]